EXHIBIT 20

CGA P-1—2015

STANDARD FOR SAFE HANDLING OF COMPRESSED GASES IN CONTAINERS

TWELFTH EDITION

CGA
Compressed Gas Association
The Standard For Safety Since 1913

PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review, and users are cautioned to obtain the latest edition. The Association invites comments and suggestions for consideration. In connection with such review, any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard. Proposed changes may be submitted via the Internet at our web site, www.cganet.com.

This document should not be confused with federal, state, provincial, or municipal specifications or regulations; insurance requirements; or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding unless adopted by reference in regulations.

A listing of all publications, audiovisual programs, safety and technical bulletins, and safety posters is available via the Internet at our website at www.cganet.com. For more information contact CGA at Phone: 703-788-2700, ext. 799. E-mail: customerservice@cganet.com.

Work Item 12-042
Safety and Health Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Normative) is a requirement.

TWELFTH EDITION: 2015
ELEVENTH EDITION: 2008
TENTH EDITION: 2006
NINTH EDITION: 2000

Contents **Page**

Appendix

Appendix Figures

1 Introduction

Users of compressed gas shall become familiar with the properties and inherent hazards of the products they use. Valuable information about each specific gas is contained in its product labeling and safety data sheet (SDS). Read this information and inform others of the importance of understanding and applying the precautions established within the available safety literature.

The user is cautioned that hazard classification systems exist for labeling, storage, transportation, security, and other purposes, particularly from regulatory agencies, which can result in a different assessment of the hazard. In addition, there can be additional hazards not addressed in this standard; therefore, the user should consult the gas supplier's SDS for specific information. See Title 29 of the U.S. *Code of Federal Regulations* (29 CFR); CGA C-7, *Guide to Classification and Labeling of Compressed Gases*; and CGA P-19, *CGA Recommended Hazard Ratings for Compressed Gases* [1, 2, 3].[1] The user should perform due diligence to research any necessary codes or regulations that can affect the use of these products.

2 Scope

This standard is primarily for the users of compressed gases in containers and is based upon accepted good practices. This standard also contains precautions that are applicable to gas suppliers and distributors. It should not be assumed that all applicable safety and security precautions or regulations are contained here.

The term "container" as used in this publication shall refer to portable compressed gas cylinders and liquid containers made in accordance with the U.S. Department of Transportation (DOT), Transport Canada (TC), or the American Society of Mechanical Engineers (ASME) specifications [4, 5, 6]. Additional information covering small cylinders can be found in CGA SB-27, *Safe Use and Handling of Small Cylinders* [7].

Additional information and requirements contained in CGA P-2, *Characteristics and Safe Handling of Medical Gases*, and other related publications it references should be reviewed when handling medical gases [8].

3 Definitions

For the purpose of this standard, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall
Indicates that the procedure is mandatory. Shall is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should
Indicates that a procedure is recommended.

3.1.3 May
Indicate that the procedure is optional.

3.1.4 Will
Is used only to indicate the future, not a degree of requirement.

3.1.5 Can
Indicates a possibility or ability.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2 Technical definitions

3.2.1 Absolute pressure
Based on a zero pressure reference point such as the perfect vacuum at normal temperature and pressure.

NOTE—Absolute pressure is commonly denoted as psia or kPa, abs.[2]

3.2.2 Apparatus
Accessory equipment such as valves, pressure relief devices (PRDs), regulators, etc., used with compressed gas containers.

3.2.3 Charging
Synonym sometimes used by regulatory agencies for the word filling.

3.2.4 Compressed gas

3.2.4.1 Flammable gas
Any material that is a gas at 20 °C (68 °F) or less and 101.3 kPa, abs (14.7 psia) of pressure (a material that has a boiling point of 20 °C [68 °F] or less at 101.3 kPa, abs [14.7 psia]) that:

- is ignitable at 101.3 kPa, abs (14.7 psia) when in a mixture of 13% or less by volume with air; or
- has a flammable range at 101.3 kPa, abs (14.7 psia) with air of at least 12% regardless of the lower limit.

The limits specified shall be determined at 101.3 kPa, abs (14.7 psia) of pressure and a temperature of 20 °C (68 °F) in accordance with ASTM E681-09, *Standard Test Method for Concentration Limits of Flammability of Chemicals* or other approved equivalent methods [10].

3.2.4.2 Nonflammable, nonpoisonous compressed gas
Any material (or mixture) that:

- exerts in the packaging an absolute pressure of 280 kPa, abs (40.6 psia) or greater at 20 °C (68 °F); and
- does not meet the definition of a flammable gas or gas poisonous by inhalation [4].

3.2.4.3 Gas poisonous by inhalation (toxic gas)
Any material that is a gas at 20 °C (68 °F) or less and a pressure of 101.3 kPa, abs (14.7 psia) (a material that has a boiling point of 20 °C [68 °F] or less at 101.3 kPa, abs [14.7 psia]) that:

- is known to be so toxic to humans as to pose a hazard to health during transportation; or
- in the absence of adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals it has an LC_{50} value of not more than 5000 mL/m^3 [4].

NOTE—LC_{50} values for mixtures can be determined using the formula in 49 CFR Part 173.133(b)(1)(i) or CGA P-20, *Standard for Classification of Toxic Gas Mixtures* [4, 11].

NOTE—Regulations such as 29 CFR and the *Globally Harmonized System of Classification and Labelling of Chemicals* can have different LC_{50} threshold values for classifying gases as toxic [1, 12]. As a result, additional requirements for these gases can be imposed on the user.

NOTE—Some local codes and ordinances use the term toxic to define those gases that have LC_{50} values less than or equal to 2000 ppm and highly toxic for gases that have LC_{50} values less than or equal to 200 ppm. As a result, additional requirements for these gases can be imposed on the user.

3.2.5 Container owner
Business or individual holding the legal title for the container(s).

---

[2] kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per CGA P-11, *Metric Practice Guide for the Compressed Gas Industry* [9].

3.2.6 Containers (compressed gas)
Vessels meeting the specifications of ASME, TC, or DOT of various shapes, sizes, and materials of construction, and designs.

NOTE—Containers include cylinders, portable tanks, spheres, or stationary tanks.

3.2.7 Corrosive gas
Gas that when in contact with living tissue causes destruction of the tissue by chemical action.

NOTE—This term shall not refer to action on inanimate surfaces.

3.2.8 Cryogenic liquid
Refrigerated liquefied gas having a boiling point colder than –90 °C (–130 °F) at 101.3 kPa, abs (14.7 psia).

3.2.9 Cryogenic liquid container
Pressurized, double-walled, insulated container used to hold either cryogenic liquefied gas or refrigerated liquefied gas.

3.2.10 Cylinder
Pressure vessel designed for pressures higher than 40 psia (276 kPa, abs) and having a circular cross section. It does not include a portable tank, multiunit tank car tank, cargo tank, or tank car [4].

3.2.11 Dewar
Open-mouthed, nonpressurized, vacuum-jacketed or insulated vessel designed to hold cryogenic liquids.

3.2.12 Distributor
Business engaged in the sale and/or resale of compressed and liquefied gases.

3.2.13 Gas pressure
Force per unit of area exerted by a gas on its surroundings.

NOTE—In the United States, gas pressure is commonly designated in pounds per square inch (psi). The analogous SI unit is the kilopascal (kPa). One psi equals 6.895 kPa. Another term used to express gas pressure is bar; one bar equals 14.5 psi.

3.2.14 Gas service
Specific type of gas for which a container and its apparatus are designed and used.

3.2.15 Gas supplier
Business that produces, fills, and/or distributes compressed gases.

3.2.16 Gauge pressure
Pressure above or below local atmospheric pressure; therefore, absolute pressure (psia or kPa, abs) minus local atmospheric pressure (psia or kPa, abs) equals gauge pressure.

NOTE—Gauge pressure is commonly designated by the abbreviation psi or kPa.

3.2.17 Handling
Moving, connecting, or disconnecting a compressed or liquefied gas container under normal conditions of use.

3.2.18 Inert gas
A nonreactive, nonflammable, noncorrosive gas such as argon, helium, krypton, neon, nitrogen, and xenon [13].

3.2.19 Liquefied petroleum gas (LPG)
Butane, isobutane, propane, propylene (propene), butylenes (butenes) and any mixtures of these hydrocarbons.

3.2.20 Manifold
Gas distribution system that transfers product through multiple outlets/inlets to compressed gas containers.

3.2.21 Nesting
Method of securing flat-bottom cylinders upright in a tight mass using a contiguous three-point contact system whereby all cylinders within a group have a minimum of three points of contact with other cylinders, walls, or bracing.

NOTE—See Appendix A.

3.2.22 Nonrefillable cylinder
Cylinder designed and constructed in accordance with DOT or TC regulations and, by those regulations, is only allowed to be filled once [4, 5].

3.2.23 Normal temperature and pressure
Temperature of 20 °C (68 °F) and an absolute pressure of 101.325 kPa, abs (14.7 psia) [13].

NOTE—Local atmospheric pressure can deviate from this standard value because of weather conditions and the distance above or below sea level.

3.2.24 Oxidizing gas
A gas that can support and accelerate combustion of other materials more than air does [13].

3.2.25 Pressure regulator
Mechanical device used to control the discharge pressure of a compressed gas from a container.

3.2.26 Pressure relief device
Pressure and/or temperature-activated device used to prevent the container's pressure from rising above a predetermined maximum, and thereby preventing rupture of a normally charged container when subjected to a standard fire test required by DOT or TC regulations [4, 5].

NOTE—The term pressure relief device (PRD) is synonymous with safety relief device as used in DOT and TC regulations.

3.2.27 Pyrophoric gas
Gas that ignites spontaneously in air at or below a temperature of 130 °F (54 °C).

3.2.28 Regulations
Federal, state, provincial, territorial, or local laws to which the handling of compressed gas containers shall comply.

3.2.29 Safety data sheet (SDS)
Written or printed information concerning a hazardous material prepared in accordance with the provisions of Title 29 of the U.S. *Code of Federal Regulations* (29 CFR) Part 1910.1200 in the United States and in Canada, the federal *Hazardous Products Act* and *Controlled Products Regulations* (CPR), and provincial *Workplace Hazardous Materials Information System Regulations* (WHMIS) [1, 14, 15].

3.2.30 Transfilling
Transfer of cryogenic liquid and/or compressed gas from one container to another.

3.2.31 Use
Act of withdrawing and applying the product gas in a nonrecoverable manner for applications other than manufacturing and/or repackaging of compressed gases.

3.2.32 User
Individual, group, or business entity that uses the containerized gas in a nonrecoverable manner.

3.2.33 Valve outlet caps and plugs
Device that serves as a pressure barrier against leakage out of the valve outlet and provides a protective covering against contamination from external sources.

3.2.34 Valve outlet dust caps and plugs
Removable attachment that provides valve thread protection and a protective covering against contamination from external sources.

3.2.35 Valve protection cap
Rigid removable cover provided for container valve protection during handling, transportation, and storage.

3.2.36 Valve protection device
Device attached to the neck ring or body of the container for the purpose of protecting the container valve from being struck or damaged by impact resulting from a fall or an object striking the container in accordance with 49 CFR and CSA B340, *Selection and Use of Cylinders, Spheres, Tubes, and Other Containers for the Transportation of Dangerous Goods, Class 2* [4, 16].

4 Regulations and standards applicable to compressed gases in containers

4.1 Transportation regulating authorities

In the United States, the transportation, safety, and security of compressed gases in containers is regulated by DOT through the modal administrators: highway by the Pipeline and Hazardous Materials Safety Administration and the Federal Motor Carrier Safety Administration, rail by the Federal Railroad Administration, and air by the Federal Aviation Administration. Transportation and security of compressed gases by water is regulated by the U.S. Coast Guard under the authority of the Department of Homeland Security. Most states and some municipalities also regulate the intrastate and intracity transportation of compressed gases through state and local transportation authorities.

DOT's regulations for compressed gases are also reproduced for carrier and shipper use by associations such as the Association of American Railroads, the Bureau of Explosives, and the American Trucking Association. Additional requirements for air transportation are covered by the carrier tariffs of the Air Transportation Association for domestic shipments and by the International Air Transport Association for foreign shipments.

In Canada, TC has the responsibility for the transportation of compressed gases in conjunction with provinces for all modes of transportation [5].

International shipment of compressed gases by water is governed by the International Maritime Organization [17].

4.2 Container regulations

DOT regulations in 49 CFR require that compressed gases be shipped in DOT-approved containers and maintained in accordance with DOT regulations [4]. In Canada, containers in which compressed gases are shipped shall comply with TC's *Transportation of Dangerous Goods Regulations* [5].

4.3 Container filling regulations

In the United States, containers filled for the transportation of compressed gases shall comply with DOT regulations governing the following subjects:

- ownership of the container and authorization to fill it;
- type of containers in which each gas is allowed to be shipped;
- charging of containers as to the amount of gas and conditions of filling;
- requirements for marking and labeling containers in transportation;
- requirements for qualifying, maintaining, and requalifying containers;
- conditions under which a container is allowed to be transported and the placarding of transport vehicles; and
- type(s) of PRD, where required [4].

In Canada, the filling requirements of containers are governed by TC's *Transportation of Dangerous Goods Regulations* [5].

4.4 Regulating authorities of workplace safety and health

Matters affecting safety and health in the workplace are regulated by the U.S. Department of Labor. Compressed gas containers shall be marked, labeled, stored, handled, and used in accordance with applicable Occupational Safety and Health Administration (OSHA) standards as well as other federal, state, territorial, and local regulations [1].

In Canada, workplace safety and health is covered by federal and provincial/territorial occupational safety and health regulations including the federal *Controlled Products Regulations* (CPR) and provincial *Workplace Hazardous Materials Information System Regulations* (WHMIS) [14, 15].

5 General safe handling rules for compressed gas containers

5.1 Personnel

Compressed gases shall only be handled and used by persons trained in their safe handling and use.

5.2 Content identification

Containers offered for shipment in North America shall have their contents identified as prescribed by DOT and TC. Containers may have the contents identified in accordance with Appendix A of CGA C-7 [2]. Content identification should be applied to the container before its removal from the filling manifold or when mixtures are analyzed. The identifications shall be present during the transportation and delivery to user.

OSHA requires that physical and health hazards and precautions be identified on each container [1]. CGA C-7 includes precautionary and warning information for each of the gases listed in that publication [2].

In Canada, identification shall be in compliance with TC's *Transportation of Dangerous Goods Regulations,* CPR, and provincial WHMIS regulations [5, 14, 15].

5.2.1 Labels

The labels applied by the gas supplier to identify the container contents shall not be defaced or removed by the user.

5.2.2 Color markings

The container color shall not be used as the primary method to identify its content. The primary identifier is the container label. Medical gas containers shall be color marked in accordance with CGA C-9, *Standard Color Marking of Compressed Gas Containers for Medical Use*, and CGSB 24.2-M86, *Identification of Medical Gas Containers, Pipelines and Valves* [18, 19].

5.2.3 Unidentified container contents

Containers not bearing a legibly written, stamped, or stenciled identification of the contents shall not be used. They shall be segregated for return to the gas supplier or distributor. Refer to CGA P-22, *The Responsible Management and Disposition of Compressed Gases and their Cylinders,* for guidance in dealing with containers with unknown contents [20].

5.3 User responsibilities

Containers are provided by the gas supplier as a convenient device for storing and delivering a gaseous product to the user. The user is responsible for the safe handling, use, and storage of the container and its contents and for returning the container to the gas supplier or distributor in the same safe condition that it was received. The following precautions concerning the container and its apparatus shall be observed by the user:

- Container maintenance—Maintenance of the container and its valve or PRD (if required) shall be performed only by trained personnel under the direction of the container owner or an authorized representative;

- Prescribed markings—The prescribed stamped or other permanent-type markings on the container shall be kept in a legible condition. The user shall not add, remove, or alter any of these markings;
- Container modifications—The user shall not modify, tamper with, paint, deface, obstruct, remove, or repair any part of the container including the PRD and the container valve or the valve protection device;
- Contamination—Contamination can occur when foreign substances enter the container or valve. If this has happened or even if the possibility exists, the user shall identify and clearly mark the container and notify the gas supplier of the details of the contamination including the container serial number; and
- Workplace risk assessment—The user shall assess the environment where containers are being stored or used to ensure conditions in the environment are conducive to the gas and container (for example, steel cylinders shall not be used near a magnetic resonance imager [MRI] and flammable gases shall not be stored in areas that do not meet electrical code classifications).

5.4 General precautions

The following precautions shall apply to distributors, users, gas suppliers, and waste gas disposal companies when using or handling compressed gas containers:

- Containers shall not be used as rollers, supports, or for any purpose other than to contain and use the contents as received;
- Containers shall not be placed where they might become part of an electrical circuit. When compressed gas containers are used in conjunction with electric welding, they shall not be grounded or used for grounding. These precautions prevent the container from being damaged by the electric welding arc;
- Containers shall not be exposed to temperature extremes. High temperatures can result in excessive pressure. Never apply a flame or heat directly to any part of a compressed gas container or allow it to come in contact with an electrically energized system. High temperatures also can damage the physical integrity of the container. If ice or snow accumulates on a container, thaw at room temperature or with water that is at a temperature not exceeding 125 °F (51.7 °C);
- If containers have been exposed to fire, contact the gas supplier immediately. Do not ship these containers unless authorized by the gas supplier;
- Containers shall not be subjected to artificially created low temperatures without the approval of the gas supplier. Many steels undergo significantly decreased impact resistance and ductility at low temperatures;
- Leaking or defective components (valve, caps, seals, PRDs, cylinders, etc.) shall not be offered for shipment. Consult the gas supplier for advice under these circumstances;
- When a container or valve is noticeably corroded, dented, cut, damaged, or involved in an accident (dropping, struck, etc.), notify the gas supplier and follow the provided instructions;
- Changing of gas service shall be performed by a gas supplier in accordance with CGA C-10, *Guidelines to Prepare Cylinders and Tubes for Gas Service and Changes in Gas Service* [21];
- Compressed gas streams should not be directed toward any person. This could cause serious injury to the eyes or body; and
- Nonrefillable cylinders shall not be refilled with any material after use of the original contents. After usage, dispose of such cylinders in accordance with the cylinder manufacturer's recommendations.

5.5 Valve protection caps and valve outlet caps and plugs

Valve protection caps for a full or partially full cylinder designed to accept a cap shall always be in place and hand-tight except when these cylinders are in process or connected for use. The user should not switch caps since not all gas suppliers use the same cap threads. A cracked or dented cap should be brought to the attention of the gas supplier.

Inserting tools such as screwdrivers that are not designed for the removal of valve protection caps through the vent hole can lead to valve damage or the inadvertent activation of the valve and the release of cylinder con-

tents. Such releases can lead to dangerous situations including fire, oxygen-deficient atmospheres, or toxic atmospheres. Use suitable tools in accordance with the manufacturer's instructions or consult the gas supplier for guidance to remove caps that are stuck or difficult to remove.

Where either gas-tight valve outlet caps and/or plugs or valve outlet dust caps and/or plugs are provided by the gas supplier, the user shall keep the device on the valve outlet at all times except when containers are secured and connected to dispensing equipment.

Gas-tight valve outlet caps and plugs serve the purpose of containing any residual product and, in accordance with the provisions of 49 CFR 173.40 and CSA B340, are mandatory for poison gas containers but also are permitted to be used for other products [4, 16]. The gas-tight valve outlet cap or plug shall be checked and tightened securely before return shipment to the gas supplier.

5.6 Safe handling of containers

Users of compressed gas containers shall ensure that they are not rolled in the horizontal position or dragged. A hand truck or cart designed for cylinders, forklift truck, cylinder pallet system, or similar material-handling device should be used with the container secured to the device. Caution shall be used when handling containers to guard against dropping or permitting containers to violently strike against each other or other surfaces.

Personnel who handle containers shall be trained in the safe handling and storage of compressed gases in containers and instructed never to lift containers using the valve protection cap or with magnets.

Ropes, chains, or slings shall not be used to suspend containers unless the container was originally designed and manufactured with lifting attachments. When lifting attachments are not provided on the container, suitable cradles or platforms to hold the containers shall be used for lifting. Never weld lifting attachments or other attachments to containers.

5.7 Transfilling

The transfer of compressed gases from one container to another shall be performed only by the gas supplier or by personnel who are:

- trained in and use equipment designed for this purpose; and
- trained in and follow written operating procedures that include the precautions necessary to avoid the product's hazards and that comply with government standards and regulations.

The supplier of the transfill equipment shall provide detailed written operating instructions that include equipment inspection and maintenance procedures.

Transfilling of gaseous and liquid oxygen for respiration shall be done in accordance with CGA P-2.5, *Transfilling of High Pressure Gaseous Oxygen Used for Respiration*, and P-2.6, *Transfilling of Liquid Oxygen Used for Respiration*, respectively [22, 23]. Transfilling of carbon dioxide is allowed when permitted by the container owner and done in accordance with CGA G-6.8, *Transfilling and Safe Handling of Small Carbon Dioxide Cylinders* [24].

5.8 Storing containers

5.8.1 Posting

Hazard warnings shall be prominently posted in container storage areas in accordance with federal, state, provincial, territorial, or local regulations. The hazard class or the name of the stored gas may be used when allowed. NO SMOKING signs shall be posted in accordance with local regulations.

5.8.2 Storage areas

Storage areas shall be designed to accommodate the various containers of gases required by the user. Segregation by partitioning or by spacing in accordance with applicable codes shall be provided so containers can be grouped together by the hazard class of the gas. Additional consideration should be given to segregating full

and empty containers. Further design consideration shall include well-drained, well-ventilated areas, preferably of noncombustible construction. Storage in subsurface locations shall be in accordance with applicable codes. Users shall ensure that there is separation from combustibles as specified by federal, state, provincial, territorial, and local regulations. Containers shall not be stored where they are exposed to flammable liquids such as gasoline. Furthermore, containers should not be exposed to salts, corrosive chemicals, or fumes. Corrosion can damage the containers and cause the container valve protection caps to stick.

Vehicles, enclosures, or other storage areas used to store cylinders shall not be allowed to exceed 125 °F (51.7 °C). Trunk and passenger areas of vehicles can exceed this temperature during sunny or warm weather. Containers shall not be stored adjacent to artificial heat sources that can raise the temperature of the container above 125 °F (51.7 °C).

Ensure that containers stored or used in public areas are protected against tampering and damage. Containers shall be protected from objects that can produce a harmful cut or other abrasion in the surface of the metal. Containers shall not be stored:

- where heavy moving objects can strike or fall on them;
- where they obstruct walkways, exit routes, or other areas normally used or intended for the safe exit of personnel;
- near elevators; or
- at unprotected platform edges.

5.8.3 Outdoor storage

Cylinders are allowed to be stored in the open. To prevent bottom corrosion, avoid prolonged exposure to a wet environment such as mud or standing water. It is preferable to store cylinders on paved surfaces such as asphalt or concrete that is graded to prevent accumulation of water. Cylinders shall not be exposed to direct sunlight outdoors where ambient temperatures exceed 125 °F (51.7 °C) unless designed for use at elevated temperature conditions. The use of a weather-protective structure or shaded environment for storage or use shall be permitted as a means to protect against direct exposure to sunlight. If the gas supplier recommends storage in the shade for a particular gas, observe such recommendations.

5.8.4 Cylinder positions in storage

All compressed gas cylinders in service or in storage at user locations shall be secured to prevent falling or rolling. At gas suppliers' facilities and distributors' warehouses, the nesting of cylinders is an equivalent means of securement (see Appendix A). Secured gas cylinders may be allowed to be stored in a horizontal position except as noted in this publication.

The method(s) used to secure cylinders can be dependent on seismic risk and shall be in accordance with local and/or provincial/territorial building and fire prevention codes.

Liquefied compressed gas cylinders shall always be stored with the PRD in direct communication with the vapor space of the cylinder. It should be noted that there are liquefied flammable compressed gas cylinders designed to be stored in the horizontal position with the PRD in direct communication with the vapor phase (for example, liquefied compressed gas cylinders used on forklift trucks and tow motors).

Cryogenic liquid containers shall always be stored upright.

5.9 Connecting a container and withdrawing its content

Container valve connections that do not fit shall not be forced. Threads on regulator connections or other auxiliary equipment shall match those on the container valve outlet. The valve outlet connection should conform to recognized standards such as CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* [25].[3] It is acknowledged that connections other than those found in CGA V-1 can exist [25]. If a user chooses such a connection, take extreme care to ensure that such connections do not cross connect with exist-

[3] This standard includes detailed dimensional drawings of standard cylinder valve outlet and inlet connections.

ing connections in CGA V-1 and that they have been engineered for the intended gas service and pressure [25].

Adapters that can change the container's CGA connection from one product to another shall not be permitted by users. Same-product-to-same-product reducers are not covered by this paragraph. Adapters used in medical service can have additional requirements.

5.9.1 Container valve

The container valve shall be kept closed at all times (charged or empty) except when the container is in use. Valve outlets shall be pointed away from personnel when the valve is being opened.

5.9.1.1 Manually operated valve

The container valve shall be opened slowly. On valves without handwheels, use the wrenches provided or recommended by the gas supplier. The wrench shall remain on the valve while the container is in use. On valves with handwheels, do not use tools such as wrenches and hammers when attempting to open or close valves. Torque wrenches designed for use with the container valve handwheels are acceptable. Contact the gas supplier if the valve is difficult to operate.

5.9.1.2 Automatically operated valve

Automatically operated valves shall be operated in accordance with manufacturers' instructions.

5.9.2 Check valves

Compressed gas containers should not be attached to a process where the container can be contaminated by the backflow of other process materials. In cases where such a possibility can exist, design considerations shall include the use of check valves and/or traps to prevent backflow. These check valves and/or traps shall be checked and maintained on a regular schedule to ensure proper operation.

5.9.3 Manifold

When compressed gas containers are connected to a manifold, the manifold and its related equipment such as regulators and safety devices shall be designed for the product(s) they are to contain at the appropriate temperatures, pressures, and flows.

5.9.4 Gas-tight connections

Piping, regulators, and other apparatus shall be kept gas-tight to prevent leakage. This can be confirmed by the use of a compatible leak test solution or an appropriate leak detection instrument.

CAUTION: *Do not tighten connections or leaking fittings or attempt other repairs while the system is under pressure.*

5.9.5 Residual container pressure

When using a nonliquefied compressed gas from a container (except acetylene), the pressure should not be reduced below the operating pressure of the system or not less than 20 psi (138 kPa) to prevent the backflow of atmospheric air or other contaminants into the container. Acetylene shall never be used in its free state at pressures in excess of 15 psi (103 kPa). The container valve shall be closed hand-tight to retain this residual pressure.

5.9.6 Removing the pressure regulator

Before a regulator is removed from a container, close the container valve and relieve the regulator of gas pressure.

5.9.7 Changing equipment service

Regulators, gauges, hoses, and other apparatus provided for use with a particular gas or group of gases shall not be used on containers of gases having different chemical properties or service pressure ratings unless information obtained from the gas supplier indicates that this can be done safely. As an example, only pressure-regulating devices approved for use with oxygen shall be used in oxygen service.

5.9.8 Pressure regulator

A suitable pressure-regulating device shall be used where gas is admitted to a system of lower pressure rating than the supply pressure and where, due to the gas capacity of the supply source, the system rating can be exceeded. A pressure regulator is required regardless of the existence of a PRD protecting the lower pressure system.

NOTE—A pressure regulator does not provide a positive means of gas backflow prevention.

5.9.9 System pressure relief device

A suitable PRD shall be used to protect a system using a compressed gas where the system has a pressure rating less than the compressed gas supply source and where, due to the gas capacity of the supply source or for any other reason, the system pressure rating can be exceeded.

5.9.10 Pigtails

Polytetrafluoroethylene (PTFE)-lined pigtails are used in the filling and discharging of compressed gas cylinders. The design and use of PTFE-lined pigtails shall be in accordance with CGA E-9, *Standard for Flexible, PTFE-Lined Pigtails for Compressed Gas Service* [26].

5.10 Transportation in passenger vehicles

The transportation of compressed gas cylinders in unsuitable or closed-bodied vehicles can present the following serious safety hazards. Refer to CGA PS-7, *CGA Position Statement on the Safe Transportation of Compressed Gas Cylinders and Cryogenic Liquid Containers in Passenger Vehicles,* for guidance [27].

- Leaks can develop for a variety of reasons. Container leaks can be due to corrosion, cracking, poor maintenance and care, or damage. Valve leaks can be due to improper blocking or securing of cylinders or inadequate valve protection. Leaks from PRDs can occur from extended confinement in an enclosed compartment (trunk or passenger compartment) that is subjected to excessive heating;
- Leaking flammable gases can present a serious fire and/or explosion hazard. Transport liquefied flammable gas cylinders in the upright position, unless designed for horizontal orientation. The PRD shall always be in direct communication with the gas phase [4]. Never put cylinders in trunks of cars or unventilated areas of passenger vehicles;
- Oxidizing gases, while not flammable themselves, present additional hazards. In the presence of an ignition source and fuel, they can support and vigorously accelerate combustion in an enclosed vehicle;
- Inert gases can cause asphyxiation in an enclosed vehicle by displacing the oxygen in air that is necessary to sustain life;
- Shipping compartments can overheat and create a hazard from a gas container that catches fire, explodes, or releases pressure. The trunk and passenger area of a vehicle can reach temperatures in excess of 125 °F (51.7 °C) quite easily on a warm or sunny day, especially when the vehicle is parked in the sun; and
- Shipping compartments can accumulate leaking gases and present a fire, explosion, or exposure hazard if not ventilated to allow for air flow and cooling.

5.11 Emergency response

An emergency response plan shall be in place wherever compressed gas containers and products are used, handled, stored, or disposed of, according to 29 CFR 1910.120 [1]. The following are precautions and information that shall be considered during the planning process.

5.11.1 Qualified personnel

Only trained personnel shall respond to an emergency situation involving a compressed gas container or product.

5.11.2 Maintain safe clearance

Personnel shall be promptly evacuated from the immediate area in danger and kept upwind at a sufficient distance to avoid any inhalation or contact with potentially hazardous products until safe re-entry can be ensured.

5.11.3 Identify hazards

Placards, container labels, and markings when observed at a safe distance provide valuable information in identifying the products involved. Once the product(s) is clearly identified, the appropriate SDS or other recognized emergency response guides should be consulted for specific hazards, precautionary safety, and related emergency response information.

5.11.4 Protective equipment

The selection of protective equipment for an emergency response situation depends on the hazards involved. No entry into the immediate danger zone should be attempted until there is an assessment of the hazards.

Where respiratory protection is required due to products presenting toxic, corrosive, or asphyxiation hazards, only an approved positive pressure self-contained breathing apparatus (SCBA) shall be used and only where there are a minimum of two units, one of which shall be in the possession of a qualified back-up person present at the scene.

5.11.5 Emergency assistance

In the event of an emergency, contact emergency response personnel (e.g., fire department) and then contact the gas supplier or distributor. Professional emergency response advice and assistance for hazardous materials in transport is also available 24-hours-a-day, 7-days-a-week throughout the United States by telephoning the Chemical Transportation Emergency Center (CHEMTREC).[4] The gas supplier and CHEMTREC telephone numbers should be immediately accessible along with other emergency response numbers including those for police, fire, and medical assistance.

In Canada, the Canadian Transport Emergency Centre (CANUTEC), the emergency center for TC, supplies a 24-hour response assistance system for transportation emergencies.[5] Canadian regulations require that when transporting certain gases an emergency response assistance plan (ERAP) be approved by TC.

6 Safe handling and storage rules for compressed gas by hazard class

6.1 Hazard class

Gases are classified based upon their chemical and physical hazards. Personnel handling or using compressed gases, or working in areas where gas containers are present, shall have an adequate knowledge of the container contents to maintain safe operating conditions.

Gases can represent a hazard because they are:

- flammable;
- an asphyxiant (inert);
- oxidizing;

[4] Chemical Transportation Emergency Center (CHEMTREC), American Chemistry Council, 700 Second St., NE, Washington, DC 20002. www.chemtrec.com

[5] Canadian Transport Emergency Centre (CANUTEC), 330 Sparks St., Office 1415, Place de Ville, Tower C, Ottawa, ON K1A 0N5, Canada. www.tc.gc.ca/canutec

- corrosive;
- toxic;
- extremely cold (cryogenic);
- under high pressure;
- liquefied; or
- pyrophoric.

Some gases can combine several of these hazards. For example, a cylinder of hydrogen gas has both high pressure and flammable hazards. Liquid argon combines the asphyxiant hazard with the low temperature hazard.

A brief description of the main classifications follows. However, more specific chemical and physical property information can be obtained from the SDS and is published in CGA's *Handbook of Compressed Gases* [28].

Partially full compressed gas cylinders containing residual gases shall be considered as full for the purpose of determining the product hazards.

6.2 Flammable gases

6.2.1 General

Flammable gases are generally defined by DOT and TC as those gases that form a flammable mixture when mixed with air in concentrations of 13% or less (by volume), or the flammable range with air is wider than 12% regardless of the lower limit [4, 5]. These limits shall be determined at 14.7 psia (101.3 kPa, abs) of pressure and a temperature of 68 °F (20 °C). There can be other gases that exhibit flammable properties but do not meet DOT's definition. The user shall always refer to the SDS of the gas for specific information on its hazards.

The major hazard associated with the handling of flammable compressed gases is fire. The three basic conditions that need to be met simultaneously to ignite a flammable gas are:

- a concentration of the gas (fuel) within the flammable limits;
- air or an oxidizing gas; and
- a source of ignition.

Flammable gases shall be stored in well-ventilated areas. Flammable gases shall be stored away from oxidizers, open flames, sparks, and other sources of heat or ignition. NO SMOKING signs shall be posted around the storage area of buildings or at entrance(s) to storage rooms. A flame shall not be used for detection of flammable gas leaks. Either a flammable gas leak detector or compatible leak detection fluid shall be used (see CGA V-12, *Leak Detection Fluids Use with Gas Cylinder Packages)* [29].

Flammable gases shall be used in well-ventilated areas and in accordance with the equipment supplier's recommendation.

Flammable gases stored outdoors where ambient temperatures exceed 125 °F (51.7 °C) shall be protected from direct sunlight. The use of a weather-protective structure or shaded environment for storage or use shall be permitted as a means to protect against direct exposure to sunlight.

CGA does not recommend gas-detection systems for outdoor use. Conditions of outdoor storage such as wind, humidity, and no enclosures make detecting flammable gas unreliable.

6.2.2 Acetylene

Acetylene containers in service or in storage at user locations shall be positioned with the valve end up (the container axis may be inclined as much as 45 degrees from the vertical) to lessen the possibility of solvent be-

ing discharged. Gas suppliers and distributors may store containers that have been secured to prevent falling or rolling in a horizontal position.

Containers or cylinders with a water volume of 1.3 gal (5 L) or less are allowed to be stored and used in a horizontal position [13].

6.2.3 Portable fire extinguishers

Portable fire extinguishers (carbon dioxide or dry chemical types) or other fire protection or suppression systems or devices shall be available for fire emergencies at storage installations. Only trained personnel shall be allowed to operate fire extinguishers.

6.2.4 Electrical equipment

Electrical equipment shall comply with the applicable electrical code.

6.2.5 Nonsparking tools

Nonsparking tools should be used with or on flammable gas cylinders and systems.

6.2.6 Storage

Provisions shall be made to protect adjoining buildings, equipment, property, and concentrations of people from hazardous exposure to flammable gases. The storage area shall be well ventilated. Heating shall be by steam, hot water, or other indirect means. Direct heating by flames or fire shall be PROHIBITED. Electrical equipment and control of sources of ignition shall be in accordance with the requirements of the applicable codes. The interior and the area surrounding the exterior of a storage building should be kept free of combustible materials.

6.2.6.1 Outdoor storage

Separation distances shall be in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code* or the prevailing local and/or provincial/territorial building and fire prevention codes [13]. Within the flammable gas category, separation shall also be provided between liquefied petroleum gas (LPG) and acetylene. Separation distance shall be at least 20 ft (6.1 m). For quantities of LPG less than 1000 lb, separation from acetylene is not required.

The maximum quantity of LPG in one storage area shall not exceed 22 500 lb or 200 000 scf. Separation between storage areas shall be at least 20 ft (6.1 m). Returned cylinders that are full or partially full shall be considered as full cylinders for determination of quantity.

NOTE—The quantity of 22 500 lb is the equivalent of 25 pallets (4 ft by 4 ft), each containing nine 100-lb cylinders (net capacity) located within a 400 ft^2 area.

The minimum required distances shall not apply when fire barriers without openings or penetrations having a minimum resistance rating of 2 hours interrupt the line of sight between the storage and the exposure. To prevent the accumulation of hazardous gas concentrations, the configuration of the fire barrier shall be designed to allow natural ventilation.

6.2.6.2 Indoor storage

The construction of rooms shall be in accordance with local and/or provincial/territorial building and fire prevention codes. See the U.S. building and fire prevention codes listed in Section 10. In Canada, the national and provincial/territorial building and fire prevention codes shall be followed [30, 31].

Flammable gas containers stored indoors shall be stored in accordance with NFPA 55 or the prevailing local and/or provincial/territorial building and fire prevention codes [13]. In some occupancies, special quantity limits are applied and in others maximum quantities are imposed unless specified controls, construction, heights and area limits, and distances to exposures (separations) are in effect.

6.2.7 Emergency situations with flammable gas

If an emergency occurs involving a flammable gas such as a gas leak, fire, or explosion, personnel should immediately evacuate the area. Do not attempt to extinguish burning gas if the flow of product cannot be shut off immediately and without risk. Only trained and qualified personnel should attempt rescue or other emergency response activities.

For additional information relative to acetylene fires, see CGA SB-4, *Handling Acetylene Cylinders in Fires* [32].

6.2.8 Flammable gas systems

Flammable compressed gas systems (piping, tubing, fittings, gaskets, and thread sealants) shall be suitable for the applicable flammable compressed gas service and for the pressures and temperatures involved. Material specifications and thickness requirements for piping and tubing shall conform to ASME B31.3, *Process Piping* [34]. For acetylene piping, see CGA G-1.2, *Acetylene Metering and Piping* [34]. All lines and equipment associated with flammable gas systems shall be grounded and bonded.

6.3 Asphyxiant gases (including inert)

Asphyxiant gases can cause suffocation by displacing the oxygen in the air necessary to sustain life. OSHA defines an oxygen-deficient atmosphere as one with less than 19.5% oxygen by volume [1]. For additional information on oxygen-deficient atmospheres, see CGA SB-2, *Oxygen-Deficient Atmospheres* [35]. SCBAs or airline masks with a 5-minute escape pack shall be worn in areas containing an oxygen-deficient atmosphere.

Inert gases are chemically inactive, odorless, tasteless, and colorless, and include argon, helium, and the rare atmospheric gases such as xenon, neon, and krypton. Nitrogen is normally considered an inert gas because it does not become reactive except at high temperatures and pressures and with catalysts.

Any gas that has the potential to displace oxygen in sufficient quantities can cause asphyxiation. Only trained and qualified persons should respond to an inert gas leak. Entry into an area where an oxygen-deficient atmosphere is present requires SCBA. Shut off the source of the gas leak if there is no risk to personnel and ventilate the area. If a person has symptoms of asphyxiation, move the victim to fresh air and obtain medical attention.

6.4 Oxidizing gases

Oxidizing gases including oxygen are nonflammable gases that can support and vigorously accelerate combustion in the presence of an ignition source and a fuel. Examples of other common oxidizing gases include chlorine, fluorine, and nitrous oxide. Although oxygen is nonflammable, materials that normally do not burn in air can burn in an oxygen-enriched atmosphere. Materials that do burn in air burn more vigorously and at a higher temperature in an oxygen-enriched atmosphere. Oxygen is extremely reactive with organic materials such as oil, grease, or tar if ignited by flame, impact, or some other energy source.

6.4.1 Handling and storage of oxidizing gases

It is important that equipment used for oxygen and nitrous oxide be cleaned with oxygen-compatible materials free from oils, greases, and other contaminants. Any material used in contact with oxidizing gases shall be suitable for this type of service. Valves, piping, fittings, regulators, and other equipment used in oxygen service shall be of a material and pressure rating compatible with oxygen. Requirements for cleaning oxygen equipment are detailed in CGA G-4.1, *Cleaning Equipment for Oxygen Service* and CGA G-4.4, *Oxygen Pipeline and Piping Systems* [36, 37].

6.4.2 Oxygen concentration

The oxygen concentration in work areas other than hyperbaric chambers shall not exceed 23.5% by volume. For additional information, see CGA P-39, *Oxygen-Rich Atmospheres* and CGA P-45, *Fire Hazards of Oxygen and Oxygen-Enriched Atmospheres* [38, 39].

Where the oxygen concentration is determined to exceed 23.5% and there is an uncontrolled leak, personnel shall be evacuated from the area immediately. When clothing has become saturated with oxygen, personnel

shall be removed from the oxygen source and from potential ignition sources, and should either change their clothing or ventilate their clothes in a normal atmosphere for not less than 15 minutes by removing their coat and moving their arms and legs [38].

6.4.3 Segregation

Oxidizers shall be stored separately from flammable gas containers or combustible materials especially oil or grease. Either a distance of 20 ft (6.1 m) or a noncombustible barrier at least 5 ft (1.5 m) high having a fire resistance rating of at least 30 minutes is a minimum separation requirement. Local and/or provincial/territorial building and fire prevention codes shall be consulted for specific requirements where applicable.

6.4.4 Fluorine

Handle fluorine, the most reactive oxidizing gas, in specially passivated containers and associated equipment. For additional information, contact your gas supplier.

6.4.5 Oxygen cylinders in the offshore marine industry

Oxygen cylinders have ruptured after being used in offshore marine operations. Studies have shown that the main cause of these cylinder ruptures is the mishandling of oxygen cylinders by users who allow sea water to flow back into the cylinders once they are empty. Metallurgical tests show that sea water in a standard CTC/DOT-3A or CTC/TC-3AA or equivalent TC-3AM or TC-3AAM oxygen cylinder causes extremely rapid corrosion to the extent that the cylinder can rupture within 60 days depending on the oxygen pressure in the cylinder. The potential for a cylinder rupture from rapid corrosion due to sea water is a hazard that not only puts the user at risk but also the producer who transports, handles, and refills the cylinders.

For recommendations for the offshore marine industry to reduce the risk of rupture and potential injury from a ruptured cylinder due to rapid corrosion caused by sea water, see CGA SB-7, *Rupture of Oxygen Cylinders in the Offshore Marine Industry* [40].

6.5 Corrosive and toxic gases

Many gases used throughout industry create additional hazards other than fire, asphyxiation, or oxygen enrichment. Exposure to some gases can present serious hazards to unprotected personnel. Before using a corrosive or toxic gas, read the label and SDS information associated with the specific gas. Instruct personnel working in the immediate area where exposure to these gases can occur of the hazards of the gases. Keep exposure to these gases as low as possible and in no case should concentrations exceed the exposure limits established by OSHA in the Unites States or the WHMIS Regulations in Canada [1, 15]. Information on the current Threshold Limit Values (TLVs®) for toxic and corrosive gases is available from the American Conference of Governmental Industrial Hygienists' publication, *TLVs® and BEIs® Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices* [41].

6.5.1 Emergency precaution and required equipment

Avoid skin or eye contact with, or inhalation of, any corrosive or toxic gases. Equip areas where corrosive gases are filled or used with emergency showers and eyewash fountains. Provide the capability for prompt emergency medical treatment including first aid.

Only trained and qualified personnel shall be allowed to fill, process, or use corrosive and toxic gases. Training shall include the associated hazards of the materials, necessary precautions, protective equipment, and emergency response procedures. Make the appropriate SDSs accessible to all such personnel.

Facilities using gases within these categories shall have an emergency plan defining procedures and outlining responsibilities necessary to address emergency situations involving corrosive or toxic gases.

Consider the need for respiratory protective equipment in the development of emergency response procedures. Where such devices are used or made available, they shall be of a design and type approved for such use by the U.S. Bureau of Mines, the National Institute for Occupational Safety and Health, or other appropriate approval authority. Personnel expected to use such devices shall be trained, qualified, and fit tested as necessary.

Where SCBAs are provided, they shall be of a positive-pressure type with a minimum of two units with one being available as a backup. Such equipment shall be stored close to the area(s) where corrosive or toxic gases are used, but not in a location likely to be affected by the release of hazardous material. Only trained and qualified personnel shall be authorized to use SCBAs and only when back-up personnel and equipment are present.

6.5.2 Ventilation, storage, and site criteria

Storage of corrosive and toxic gases shall be in accordance with local and/or provincial/territorial building and fire prevention codes.

These gases shall be filled and used only in ventilated areas, exhausted enclosures, or outdoors in accordance with local and/or provincial/territorial building and fire prevention codes. If gases are emitted from equipment at concentrations greater than permitted levels, gases shall be directed to a treatment system or otherwise controlled in accordance with the local and/or provincial/ territorial building and fire prevention codes.

The user shall refer to the SDS information for additional guidance on the storage and compatibility requirements of the materials and/or contact the gas supplier. The storage or use of toxic and highly toxic gases shall be in accordance with Section 7.9 of NFPA 55 [13].

6.6 Gas mixtures

A large variety of gas mixtures can fall into one or more of the hazard classifications listed in this section. Consider the precautions recommended for the particular classes involved in handling the gas mixture. Specific information on gas mixtures is given on the product label. Additional information can be obtained from the gas supplier.

6.7 Cryogenic liquids

6.7.1 General information

Cryogenic liquids present the additional hazard of extreme cold along with the other concerns of possible hazards: pressure, flammable, oxidizing, toxic, and asphyxiant. Cryogenic liquids are gases that are handled in liquid form at relatively low pressures and extremely low temperatures, usually less than –130 °F (–90 °C). Because of their low temperatures, cryogenic liquids are handled in double-wall, vacuum-insulated containers to lessen evaporation and venting of gas. Some cryogenic liquids in small quantities are also handled in open, low pressure, thermos-type containers (dewars) in laboratory work.

Cryogenic liquids can cause thermal burns upon contact with the body. When handling cryogenic liquids, wear suitable eye protection such as a face shield and either safety glasses or safety goggles to protect against the extremely cold liquid and gas. Wear hand protection such as insulated gloves to prevent contact with cold liquid, cold gas, and cold equipment or piping. Gloves should be loose fitting so they can be readily removed if liquid splashes into them. Wear long-sleeved shirts and cuffless trousers over (outside) high-topped shoes to prevent spills from being trapped in shoes or from contacting the feet.

6.7.2 Cryogenic liquid containers and associated equipment

Store and handle containers in an upright position. The containers shall not be dropped, tipped over, or rolled on their sides. Cryogenic liquefied gas containers not equipped with wheels and with a capacity greater than 20 gal (76 L) shall be moved using a four-wheel hand truck designed for this purpose. Users shall assess the risks of handling containers with a capacity of 20 gal (76 L) or less and use an appropriate device or method to mitigate risk. Maintain hand trucks in good operating condition. Store and handle cryogenic liquefied gas containers in well-ventilated areas to prevent hazardous concentrations of the gas. Containers and equipment assigned for a specific cryogenic liquefied gas service shall not be used for the storage or use of another cryogenic liquefied gas unless such service is approved by the gas supplier.

Provide these gas containers with PRDs adequate to relieve excessive pressures within the containers. Where cryogenic liquefied gas or cold gas can be trapped in piping between valves, equip the piping with a PRD. Transfer lines designed for cryogenic liquefied gases shall only be used. It is recommended that all vents be piped to the exterior of the building. Perform the transfer of cryogenic liquids slowly enough to lessen excess evaporation and stress due to rapid cooling and contraction of warm containers and equipment. Store and

transfer cryogenic liquids under positive pressure to prevent the infiltration and solidification of moisture, air, or other gases.

All cryogenic containers have the potential for exposure to external contamination during their service life. External contamination can occur while in storage or in use in areas where contaminants are present in the form of airborne mist or particulate matter. External contamination can also occur during transportation. Road-film and salts being thrown up by vehicle traffic, oil leaks from the transport vehicle, and even unburned engine fuel can result in the accumulation of contaminants. Ambient weather and local service conditions can cause wide variations in the potential for accumulation. Such contamination is of special concern where oxidizing gases are involved.

Although it is recommended that all cryogenic containers undergo a thorough prefill inspection, additional care shall be given to some cryogenic liquid container designs to ensure that inspections address the area beneath the protective cover of the liquid level sight-glass.

6.7.3 Product-specific recommendations

6.7.3.1 Liquid oxygen

Keep liquid oxygen containers, piping, and equipment clean and free of grease, oil, and organic materials. Smoking and open flames shall not be permitted in areas where liquid oxygen is stored or transferred. Liquid oxygen systems at user sites shall comply with local and/or provincial/territorial building and fire prevention codes where applicable.

6.7.3.2 Liquid hydrogen

Smoking and open flames shall be prohibited where liquid hydrogen is stored or handled. Electrical equipment used where liquid hydrogen is stored and handled shall be rated for use in hazardous locations. Store and transfer liquid hydrogen under positive pressure to reduce the chance of infiltration and solidification of moisture, air, or other gases. Liquid hydrogen systems at user sites shall comply with local and/or provincial/territorial building and fire prevention codes where applicable.

6.7.3.3 Liquid helium and liquid neon

Store and transfer liquid helium and liquid neon under positive pressure to prevent the infiltration and solidification of moisture, air, and other gases.

6.7.3.4 Liquefied natural gas

Smoking and open flames shall be prohibited where liquefied natural gas is stored or handled. Electrical equipment used where liquefied natural gas is stored and handled shall be rated for use in hazardous locations. Store and transfer liquefied natural gas under positive pressure to prevent the infiltration of moisture, air, or other gases. Liquefied natural gas systems at utility plants and user sites shall comply with local and/or provincial/territorial building and fire prevention codes where applicable.

7 Precautions for tank cars, cargo, and portable tanks

7.1 General

Unloading operations shall be supervised by qualified person(s). Personnel shall be aware of the associated hazards of the product and equipment and understand applicable safety regulations and emergency procedures.

7.2 Tank cars

It is important that liquefied gases and cryogenic liquids be loaded only into tank cars designated and suitable for the particular gas to be charged. Obtain approval from the gas supplier before a tank car is charged with a liquefied compressed gas or cryogenic liquid other than the one for which approval has been given by the Tank Car Committee of the Association of American Railroads. In Canada, make the tank car selection in accordance with CGSB 43.147-2005, *Construction, Modification, Qualification, Maintenance, and Selection and Use*

of Means of Containment for the Handling, Offering for Transport, or Transport of Dangerous Goods by Rail [42]. Shipping instructions, diagrams for unloading, and all caution markings on the tank or dome shall be followed. Angle valves should be opened slowly to avoid closing excess-flow valves in the eduction pipe. The use of a hammer on a valve or cover plate to release a stuck excess-flow valve is prohibited.

Before unloading the product, conduct a walk-around inspection of the tank car to check for any visible unsafe conditions or defects. If defects or unsafe conditions are found, they shall be reported to the gas supplier.

Confirm the product contents of the tank car and the suitability of the transfer lines and equipment to be used to unload the product.

Never tamper with PRDs or the valves on tank cars or place your head or face over or in front of a relief valve opening. If an uncontrolled leak occurs in the tank car or fittings, isolate the car if practical and contact the gas supplier for instructions. Never disconnect a hose coupling or repair a leak in the fittings while the line is under pressure.

Railway sidings on which liquefied compressed gas or cryogenic liquid tank cars are placed for unloading should be level, have the minimum necessary clearance based on the track radius and car size, and be devoted solely to this purpose. Provide derails at one or both ends of the unloading track and/or other means such as a locked switch, gate, or barricade to prevent intrusion of other railcars into the unloading area. Chock railcars to prevent accidental movement. Electrically ground cars before unloading if their content is flammable.

7.3 Cargo tanks

Cargo tanks mounted on motor vehicles are normally not handled by the product user. However, in cases where the user handles the cargo tank, the user shall consult the gas supplier for instructions on safe handling procedures.

8 Security issues

Security is an integral part of the compressed gas industry. Safety and security measures protect facilities, employees, and the community by reducing the risks from a wide range of vulnerabilities and mitigating the effects of incidents such as vandalism, sabotage, workplace violence, theft/misuse of product, contamination, and terrorism.

Theft of compressed gases is an ongoing concern. Compressed gases have been obtained for illegal drug use, for the manufacture of illegal drugs, and for potential terrorist activities. Compressed gas containers should be secured to prevent theft for illegal activity.

Additional information can be found in the following publications:

- FDA's *Bioterrorism Act of 2002*, which provides guidance for medical products and food application [43];
- CGA P-50, *Site Security Standard*, which provides guidance to the compressed gas industry for assessing security risks and identifying and implementing preventive security measures at fixed sites [44];
- CGA P-51, *Transportation Security Standard for the Compressed Gas Industry*, which provides guidance for securing product during shipment [45];
- CGA P-52, *Security Standard for Qualifying Customers Purchasing Compressed Gases*, which provides guidance to the compressed gas industry for qualifying potential customers who purchase products that are considered at risk for illegal use [46]; and
- CGA P-53, *Security Code Top Screen*, which provides guidance to the compressed gas industry in identifying sites based on the Chemicals of Concern/Chemicals of Interest found in Table 1 [47].

8.1 Facility security

Facility security measures include, but are not limited to, the following:

- For containers and systems:

- Store containers in a secured area
- Limit access to authorized personnel only
- Maintain a product inventory and investigate any discrepancies
- Report any incidents involving thefts, misuse, or inventory shortages to law enforcement and the supplier; and

– For bulk systems:

- Provide perimeter security having a minimum height of 6 ft (1.8 m) and lockable gates
- Bollards or barriers should be used to prevent unauthorized vehicle intrusion
- Area lighting should be provided to reduce dark zones surrounding the installation, which enhances security and facilitates nighttime deliveries and maintenance.

8.2 Distribution security

Security measures improve the safe transportation of hazardous materials by reducing the risks from a wide range of vulnerabilities. Concerns about terrorism, sabotage, theft, or intentional product contamination give companies that transport hazardous materials a compelling reason to implement security measures for products that are transported. Safety and security measures protect the general public, the environment, and the compressed gas industry and its employees.

The implementation of distribution security and required training shall be in accordance with 49 CFR 172.700 and 172.800 [4]. This applies to anyone involved with shipping or transporting of hazardous materials.

Distribution security requirements vary according to the compressed gas being distributed and the mode and route of transportation. Companies involved in the transportation of hazardous materials shall have a detailed, written transportation security plan, and employees shall be trained in accordance with this plan. Detailed security information should only be shared with authorized personnel that have a need to know. All security plans shall be classified in accordance with 49 CFR Parts 15 and 1520 [4].

9 References

Unless otherwise specified, the latest edition shall apply.

[1] *Code of Federal Regulations*, Title 29 (Labor), U.S. Department of Labor, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20401. www.gpo.gov

[2] CGA C-7, *Guide to Classification and Labeling of Compressed Gases*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[3] CGA P-19, *CGA Recommended Hazard Ratings for Compressed Gases*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[4] *Code of Federal Regulations*, Title 49 (Transportation), Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20401. www.gpo.gov

[5] *Transportation of Dangerous Goods Regulations*, Transport Canada, Canadian Government Publishing, Public Works and Government Services Canada, Ottawa, ON K1A 0S9, Canada. www.tc.gc.ca

[6] ASME *Boiler & Pressure Vessel Code*, Section VIII, Div 1, ASME International, Two Park Ave., New York, NY 10016. www.asme.org

[7] CGA SB-27, *Safe Use and Handling of Small Cylinders,* Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[8] CGA P-2, *Characteristics and Safe Handling of Medical Gases,* Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[9] CGA P-11, *Metric Practice Guide for the Compressed Gas Industry*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[10] ASTM E681-09, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428. www.astm.org

[11] CGA P-20, *Standard for Classification of Toxic Gas Mixtures*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[12] *Globally Harmonized System of Classification and Labelling of Chemicals (GHS)*, United Nations Economic Commission for Europe, Palais de Nations, 1211 Geneva 10, Switzerland. www.unece.org

[13] NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169. www.nfpa.org

[14] *Hazardous Products Act* and *Controlled Products Regulations*, Health Canada, Canadian Government Publishing, Public Works and Government Services Canada, Ottawa, ON K1A 0S9, Canada. www.hc-sc.gc.ca

[15] *Workplace Hazardous Materials Information System*, Environmental and Workplace Health, Health Canada, Ottawa, ON K1A 0L2, Canada. www.hc-sc.gc.ca

[16] CSA B340, *Selection and Use of Cylinders, Spheres, Tubes, and Other Containers for the Transportation of Dangerous Goods, Class 2*, Canadian Standards Association, 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada. www.csa.ca

[17] *International Maritime Dangerous Goods Code*, International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom. www.imo.org

[18] CGA C-9, *Standard Color Marking of Compressed Gas Containers for Medical Use*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[19] CGSB 24.2-M86 *Identification of Medical Gas Containers, Pipelines, and Valves*, Canadian General Standards Board, Place du Portage III – 6B1, 11 Laurier St., Gatineau, QC K1A 1G6, Canada. www.tpsgc-pwgsc.gc.ca

[20] CGA P-22, *The Responsible Management and Disposition of Compressed Gases and their Cylinders*, 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[21] CGA C-10, *Guidelines to Prepare Cylinders and Tubes for Gas Service and Changes in Gas Service*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[22] CGA P-2.5, *Transfilling of High Pressure Gaseous Oxygen Used for Respiration*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[23] CGA P-2.6, *Transfilling of Liquid Oxygen Used for Respiration*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[24] CGA G-6.8, *Transfilling and Safe Handling of Small Carbon Dioxide Cylinders*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[25] CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[26] CGA E-9, *Standard for Flexible, PTFE-Lined Pigtails for Compressed Gas Service*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[27] CGA PS-7, *CGA Position Statement on the Safe Transportation of Compressed Gas Cylinders and Cryogenic Liquid Containers in Passenger Vehicles*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[28] *Handbook of Compressed Gases*, 5th edition, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[29] CGA V-12, *Leak Detection Fluids Use with Gas Cylinder Packages*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[30] *National Fire Code of Canada*, Canadian Codes Centre, National Research Council Canada, Building M-23A, 1200 Montreal Rd., Ottawa, ON K1A 0R6, Canada. www.nationalcodes.ca

[31] *Provincial/Territorial Fire Codes,* contact the Fire Marshall's office in the appropriate province(s).

[32] CGA SB-4, *Handling Acetylene Cylinders in Fires,* Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[33] ASME B31.3, *Process Piping,* ASME International, Two Park Ave., New York, NY 10016. www.asme.org

[34] CGA G-1.2, *Acetylene Metering and Piping*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[35] CGA SB-2, *Oxygen-Deficient Atmospheres*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[36] CGA G-4.1, *Cleaning Equipment for Oxygen Service*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[37] CGA G-4.4, *Oxygen Pipeline and Piping Systems*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[38] CGA P-39, *Oxygen-Rich Atmospheres*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[39] CGA P-45, *Fire Hazards of Oxygen and Oxygen-Enriched Atmospheres*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[40] CGA SB-7, *Rupture of Oxygen Cylinders in the Offshore Marine Industry*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[41] *TLVs® and BEIs® Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices*, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Dr., Cincinnati, OH 45240. www.acgih.org

[42] CGSB 43.147-2005, *Construction, Modification, Qualification, Maintenance, and Selection and Use of Means of Containment for the Handling, Offering for Transport, or Transporting of Dangerous Goods by Rail,* Canadian General Standards Board, Place du Portage III–6B1, 11 Laurier St., Gatineau, QC K1A 1G6, Canada. www.tpsgc-pwgsc.gc.ca

[43] *Bioterrorism Act of 2002*, Food and Drug Administration, 10903 New Hampshire Ave., Silver Spring, MD 20993. www.fda.gov

[44] CGA P-50, *Site Security Standard*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[45] CGA P-51, *Transportation Security Standard for the Compressed Gas Industry*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[46] CGA P-52, *Security Standard for Qualifying Customers Purchasing Compressed Gases*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

[47] CGA P-53, *Security Code Top Screen,* Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

10 Additional references

AWS Z49.1, *Safety in Welding and Cutting and Allied Processes,* American Welding Society, 13301 NW 47 Ave., Miami, FL 33054. www.aws.org

Code of Federal Regulations, Title 6 (Domestic Security) Part 27, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20401. www.gpo.gov

CGA AV-1, *Safe Handling and Storage of Compressed Gases*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA C-6.1, *Standard for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA C-6.2, *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA S-1.1, *Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases,* Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA S-7, *Standard Method for Selecting Pressure Relief Devices for Compressed Gas Mixtures in Cylinders*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA V-7, *Standard Method of Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CGA V-9, *Compressed Gas Association Standard for Compressed Gas Cylinder Valves*, Compressed Gas Association, Inc., 14501 George Carter Way, Suite 103, Chantilly, VA 20151. www.cganet.com

CAN/CSA Z276, *Liquefied Natural Gas (LNG) — Production, Storage, and Handling,* Canadian Standards Association, 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada. www.csa.ca

Effects of Toxic Exposure to Gases, Matheson Tri-Gas, 150 Allen Rd., Basking Ridge, NJ 07920. www.mathesongas.com

Gas Encyclopedia, L'Air Liquide, Elsevier Scientific Publishing Company, Amsterdam 197L Netherlands. www.airliquide.com

International Fire Code®, International Code Council, Inc., 5203 Leesburg Pike, Suite 708, Falls Church, VA 22041. www.iccsafe.org

International Building Code®, International Code Council, Inc., 5203 Leesburg Pike, Suite 708, Falls Church, VA 22041. www.iccsafe.org

Matheson Gas Data Book, Matheson Tri-Gas, 150 Allen Rd., Basking Ridge, NJ 07920. www.mathesongas.com

NFPA 1, *Uniform Fire Code*™, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Works*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 58, *LP-Gas Code,* National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 70, *National Electrical Code®,* National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 80, *Standard for Fire Doors and Other Opening Protectives,* National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

NFPA 101, *Life Safety Code®*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

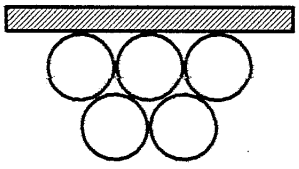
NFPA 5000, *Building Construction and Safety Code*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269. www.nfpa.org

Appendix A—Cylinder nesting (Normative)

Section 5.8.4 states that "All compressed gas cylinders in service or in storage at user locations shall be secured to prevent falling or rolling. At gas suppliers' facilities and distributors' warehouses, the nesting of cylinders is an equivalent means of securement."

Nesting depends on a three-point contact system so all cylinders shall be in contact at three points either with a secure wall or with another cylinder. Figures A-1 and A-2 show what is and what is not proper nesting.

Nested wall supported

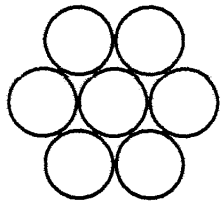


Three-point contact system

All cylinders are in contact on three points–either with other cylinders or a wall.

NOTE—This diagram shows the minimum number of cylinders necessary for this configuration.

Nested unsupported



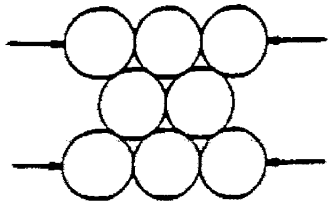
Three-point contact system

All cylinders are in contact with other cylinders on three points.

NOTE—This diagram shows the minimum number of cylinders necessary for this configuration.

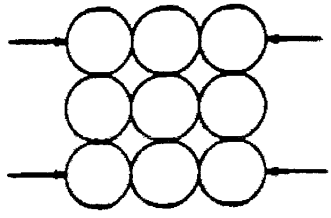
Figure A-1—Properly nested cylinders

Improperly nested cylinders



The end cylinders are in contact with other cylinders on only two points.

Improperly nested cylinders



The end cylinders are not in contact with other cylinders on three points.

Figure A-2—Improperly nested cylinders

Compressed Gas Association
14501 George Carter Way, Suite 103
Chantilly VA 20151-2923
703-788-2700
www.cganet.com